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Are EMS environmentally effective?
The link between environmental management systems and environmental performance in European companies

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Abstract

Based on the analysis of a large dataset on the environmental performance of European companies in five industrial sectors, the paper examines the question of whether the presence of an environmental management system (EMS) has a positive impact on the eco-efficiency of companies. It begins with a review of evidence about the link between EMS and environmental performance in business organisations, finding that, despite much research, there is still little quantitative evidence. The second part of the paper uses three independent statistical methods (simple correlations, Jaggi-Freedman indices and a 'trend differences' approach) to assess whether companies and production sites with EMS perform better than those without and whether performance improves after an EMS has been introduced. The paper shows that there is currently no evidence that EMS have a *consistent* and *significant* positive impact on environmental performance. Policy action based on the simple assumption that companies with an EMS perform better than those without therefore seems inappropriate.

1. Introduction

Policy instruments that rely on voluntarism, learning processes and procedural change, rather than direct regulatory control have in recent years come to play a more prominent role in the environmental policy mix of many industrialised countries. They have been promoted by those who maintain that traditional hierarchical regulation does not provide dynamic incentives for environmental improvement, and that voluntary approaches increase the cost-effectiveness of environmental protection by giving firms flexibility in making their own choices, reduce the information and administrative costs of regulation and are a way of distributing the social control of business. Critics, on the other hand, are sceptical that these 'soft' instruments can deliver real environmental improvements.

This paper contributes to the debate on the impact of new environmental policy instruments by presenting evidence on the effectiveness of one of the most prominent of these instruments: environmental management systems (EMS). It draws on the Measuring Environmental Performance of Industry (MEPI) project, which collected and analysed environmental performance data for 274 companies and 400 production sites (operated by those firms) in six manufacturing sectors in six EU countries.

The first section discusses the rationale behind the increasing adoption of voluntary and procedurally-based instruments in general, and EMS in particular. We then review existing empirical evidence regarding the link between EMS and environmental performance, based on research carried out in Germany, Austria, Switzerland, the UK and Finland. The main part of the paper presents the authors' own analysis. It is based on data collected during the MEPI research project and uses three different methods: 1) Statistical analysis on the firm-level (multiple regressions); 2) Statistical analysis on the production site-level (simple regressions); and 3) Longitudinal analysis on the production site-level. The final part draws conclusions about the potentials and limits of environmental management systems, and briefly explores the wider implications of the analysis for the role of soft policy instruments in the environmental policy mix.

2. New policy instruments and the link between environmental management and performance

Much has been written about a shift from traditional hierarchical regulation towards a different set of instruments in environmental policy-making (Andrews, 1998; Gunningham and Grabosky 1998; Coglianese and Nash, 2001; Khanna, 2001). The widely used term 'new policy instruments' includes a range of different coordinating and steering mechanisms including economic, procedural, information-based, self-regulatory, co-regulatory and voluntary instruments. They have in common that they aim to achieve their objectives by means other than the hierarchical prescription of legally-binding rules and standards which can be enforced by public authorities.

Although it can be argued whether new policies complement or replace the 'command and control' approach, it is now widely accepted that the use of alternative instruments is indeed increasing in many countries (Jordan et al 2003). Looking empirically at the factors that have led to the adoption of new environmental policy instruments in eight industrialised countries, Jordan and colleagues (2003a: 202-205) identified a range of different contributory factors, some of which relate to changing ideas and beliefs, while others stem from organisational, political and economic factors. One of the key drivers is seen to be the assumption that new instruments are a more effective way of achieving environmental improvements.

The effectiveness of these new policy instruments has been widely discussed, especially with regard to economic instruments (Tietenberg 1991; Newell et al. 1999). Here, we focus on a different range of policies that have been called 'soft instruments'. This term describes instruments that aim to achieve environmental aims without employing direct coercion through law, or induce change by altering relative prices. They include voluntary, procedural and information-based policies. Although the term ‘soft’ appears vague, it accurately describes the main characteristics of these policies: to attain environmental policy objectives without introducing legal or economic (i.e. ‘hard’) constraints. Prominent examples of soft policy instruments are environmental management systems, environmental product labelling, public disclosure requirements, best practice dissemination, industry codes of practice, and voluntary agreements.

Can soft instruments be more effective than conventional regulation? A variety of opinions exist. On the one hand, it has been shown that voluntary programmes that place the least demands on firms have attracted the highest participation rates (Davies and Mazurek, 1996). There is also evidence that even among firms that do participate in voluntary programmes, there remain a disproportionate number of poor performers and that members do not improve faster than non-members (King and Lenox, 2000). On the other hand, there are also those who find that voluntary initiatives have a positive impact on firm environmental performance. For instance, econometric analysis has shown that voluntary programmes such as the US EPA's 33/50 Program, which aimed to reduce releases and transfers of a list of toxic chemicals, did indeed induce statistically-significant declines in the releases of these chemicals (Arora and Cason, 1995; Khanna and Damon, 1999).

The intellectual basis of soft instruments is provided by recent cognitive approaches applied across the social sciences (for example Schön 1983; Dryzek 1987; Fischer 1995; Weick 1996). Cognitive approaches argue that the behaviour of actors is to a large degree determined by their subjective interpretation of reality, rather than being the outcome of 'objective' and rationally-determined interests. It follows that any attempt to change behaviour needs to be based on an understanding of the frames of interpretation, discourses and knowledge sets which influence how these actors make sense of their world and action within it, and how they respond to changes in interpretive frames, discourses and so on. More specifically, soft instruments are based on the assumption that polluting behaviour is (at least in part) the result of institutionally-situated perceptions of reality (or ignorance about the state of things). Interpretive frames that stand in the way of environmentally beneficial decisions could be, for example, the assumption that reducing environmental damage is always associated with costs, that companies do not have any environmental responsibilities beyond legal compliance, or that environmental resources are free goods.

Closely related to the first, a second argument is that by changing the sense-making of individuals and organisations, it is possible to change the attitudes and behaviours of those individuals and organisations – which, in turn, will ultimately have an impact on the environmental impacts of behaviours. This could be achieved by providing information (for example about environmental costs or best practice), through more subtle and long-term processes of learning and capacity-building, or through processes of awareness-raising about the liabilities and responsibilities of the polluter.

By encouraging organisational change, EMS are thought to have a direct impact on environmental performance. For instance, the preamble to the EMAS (Eco-Management and Audit Scheme) regulation of the European Union states:

> "The objective of EMAS shall be to promote continual improvements in the environmental performance of organisations" (EMAS regulation, Art 1.2)

These improvements in performance are to be achieved through the imposition of management controls. However, this link between management and performance cannot be taken for granted. Research has documented that improving environmental performance is not usually the principal motive in a company's decision to adopt an EMS. A business survey carried out amongst Swiss firms identified 14 reasons for implementing an EMS which were considered to be 'very important' or 'quite important' by at least half of the 158 respondents (Hamschmidt 2000). The benefits included in this list ranged from 'strengthening innovation' and 'customer loyalty' to 'prevention of new environmental legislation', with 'enhancement of corporate public image' ranking highest. Only three of the 14 had a direct relationship with performance ('risk minimisation', 'certainty of legal compliance' and 'support of ecological transformation of the line of business'), and they were ranked at positions 4, 9 and 12 (Hamschmidt 2000: 4).

3. EMS and environmental performance: Evidence from other studies

3.1 Studying the effectiveness of EMS

Since the European and international environmental management standards were introduced in the mid 1990s, it is estimated that approximately 63,500 companies and production sites have adopted a certified or registered EMS[1] worldwide, and many more systems not audited by third parties exist. The fact that there is substantial experience with environmental management in companies has triggered a large number of research projects, evaluations, dissertations and doctoral theses into the effects of EMS. It is surprising that despite the recent growth of this literature (for recent reviews see for example Dyllick and

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[1] There are around 3,500 EMAS registrations in the EU and more than 60,000 ISO 14001 certifications world wide. Data source: EMAS website (http://europa.eu.int/comm/environment/emas) [page accessed 20 June 2004] and ISO World / Umweltbundesamt (http://www.ecology.or.jp/isoworld/english/analy14k.htm) [page accessed 20 June 2004].

Hamschmidt 1999; Steger 2000; Ammenberg 2001; Coglianese and Nash, 2001; Ankele et al 2002; Schaltegger and Synnestvedt, 2002; Thornton et al, 2003; Andrews, 2003; Anton et al. 2004), empirical evidence about the environmental effectiveness of EMS is still relatively sparse. One of the reasons is that many studies have focused on the direct economic costs and benefits associated with EMS. Economic benefits, are not, however, a reliable indicator of environmental effectiveness because savings can be made without reducing pollution. For example, a company can save costs by organising environmental responsibilities better or by identifying cheaper methods of waste disposal. Conversely, the adoption of an EMS may lead to unanticipated and costly pollution abating measures. For example if the use of an EMS revealed that the firm was in breach of regulation, investment in abatement technology might be obligatory.

Even those researchers that have attempted to assess quantitatively the link between EMS and environmental performance have rarely been able to make valid statements about the overall environmental effectiveness of EMS. Several reasons may be given for this apparent anomaly. Of greatest importance, many studies suffer from a shortage of environmental performance data. In most countries, environmental reporting is not mandatory and most companies prefer not to publish quantitative performance data. ISO 14001 does not require disclosure of environmental information. Even where data on emissions, materials use or non-compliance incidents are provided in environmental reports or EMAS site statements, it is rarely presented in a comparable format. Despite the activity of organisations such as the Global Reporting Initiative, there is no standard approach to environmental reporting and measurement. Public emissions registers exist only in a few countries such as Britain, the United States and the Netherlands, and the quality and usability of the data in these registers varies. Only a few research projects have had the capacity to carry out the costly and time-consuming data work necessary to conduct comprehensive studies of the environmental performance consequences of EMS. Most studies only look at a small number of companies (Thornton et al, 2003), or rely on data generated through companies' self-assessment (Dyllick and Hamschmidt, 1999, Berry and Rondinelli, 2000; Mohammed, 2000; Florida and Davidson, 2001).

Quantitative analysis of environmental performance of companies poses a series of conceptual and methodological challenges. First, environmental performance is a complex and multi-dimensional issue. There is no universally accepted approach to the inherently subjective task of weighing different environmental impacts against each other. For instance, any overall assessment or ranking based on a judgement of how greenhouse gas emissions compare to chemical spills or special waste will produce highly contested results. It is also debatable whether the fact that companies operate in different natural environments should be taken into account when considering pollution that has local impacts. Second, companies carry out distinct business activities under different economic, technological and regulatory conditions. Some businesses will always find it more difficult to improve their environmental performance than others, even if they operate in the same sector. For example, it may be that the specific demands placed on a company by its customers prevent the adoption of a cleaner technology. Third, it is difficult to decide where the system boundaries should be set with regard to environmental performance. Are companies responsible only for damage caused by production operations, or should issues such as the supply of raw materials and components, transportation to and from the company, product use and disposal be included in the assessment of environmental performance?

Given these difficulties in establishing a robust framework for performance evaluation, most studies have used self-reported proxies that can be measured through postal or telephone surveys, for example satisfaction with the EMS, perceived environmental benefits, or types of measures put in place. Although this is a justifiable response to the challenges outlined above, the reliance on 'effort indicators' and self-assessment limits the validity of findings. It is important to recognise that conclusions are often based on the (empirically-informed) judgement of researchers and their interviewees, rather than on quantitative evidence. In the remainder of this section, we summarise the results of some of the larger and more performance-oriented studies (see Table 1).

3.2 Results from key studies

There is as yet no consensus on the question of EMS' impact on environmental performance. Many researchers reported a moderate improvement of environmental effectiveness stemming from EMS adoption (e.g. Hamschmidt 2000), even though some studies (such as UNI/ASU 1997; Kuisma et al 2001, Andrews, 2003; Anton et al, 2004) adopt a generally more optimistic tone than others (for example FEU 1998; Jäger et al 1998; Steger 2000; Wagner 2002). A considerable variability between companies was also observed (UNI/ASU 1997; Steinle and Baumast 1997; Kuisma et al 2001; Andrews, 2003).

Some research has found little evidence that EMS have driven environmental improvement (Jäger et al 1998; Steger 2000). Matthews (2001) noted '…little difference in the toxic emissions of US automobile assembly facilities with ISO14001 certification and those without…, in many cases, firms with certified EMS fared worse.' (p 1927). Wagner (2002) concludes for a sample of 306 German manufacturing firms that there were no significant differences in 2001 profitability levels and the ratios of energy consumption to sales or to employee between firms with and without EMS. Also, no positive trend was found for either profitability or energy efficiency during the period 1991 to 2001. Against this, Andrews (2003) established a consistent relationship between EMS adoption and environmental improvement. Potoski and Prakash also find some evidence that ISO140001-cerified industrial facilities in the US reduced toxic emissions faster than non-certified facilities (Potoski and Prakash, 2005), while Anton et al (2004) found a link between the comprehensiveness of environmental management systems in firms and lower toxic emissions per unit output. This confirms the suggestion that what counts is the *quality* of an EMS (Coglianese and Nash, 2001) and the environmental management style (Thornton, Kagan and Gunningham, 2003), rather than the presence of such a system. Matthews et al (2004) make a similar argument and suggest a framework for synthesising different elements of EMS and so improving performance.

TABLE 1 ABOUT HERE

There is also mixed evidence regarding the effect of EMS on legal compliance with environmental regulation. Steger (2000), Jäger et al (1998) and Andrews (2003) conclude that EMS do support compliance. Steger points out, however, that it is difficult to determine the actual environmental effects of better compliance because non-compliance is often concerned with formal infringements rather than material breaches. In contrast, Dahlström et al's (2003) study was unable to confirm this link. The study - which is one of the few analyses that draw on a comprehensive set of independent performance assessments - analyses almost 800 production sites across England and Wales using databases of operator performance as assessed by Environment Agency enforcement officers.[2] It concluded that having an EMS improves certain procedural aspects of

[2] The study linked the Environment Agency's Operator Performance and Risk Appraisal database and its enforcement database with the results of an EMS survey of 843 production sites. It used simple observational techniques as well as ANOVA tests to assess whether an externally validated EMS is associated with higher

environmental management such as recording and use of information, knowledge and implementation of authorization requirements, plant maintenance, management and training, and process operation. Crucially however, they did not find a link between the presence of an EMS and actual performance measured as complaints, non-compliance events and the likelihood (as assessed by enforcement officers) of suffering from incidents.

There are also doubts about whether EMS represent an *autonomous* driver of performance improvements. In Steger's study (2000), most respondents held the view that the environmental objectives of the company could also have been attained without an EMS. Hamschmidt (2000) reports that while most would agree that an EMS had some influence on environmental performance, only few saw it as a key factor. EMS do not appear to lead to fundamentally different environmental objectives and strategies, but promote streamlining of existing environmental responsibilities. Interestingly, external stakeholders tended to have a more positive view of the costs and benefits than companies themselves (Steger 2000).

EMS appear to be related to improvements in traditional areas of environmental management. Empirical studies of EMS in operation show that most companies focus on on-site production efficiency. The most significant improvements appear to have been made in the areas of waste management, energy use and water consumption (UNI/ASU 1997; Kuisma 2001; Steinle and Baumast 1997; Dyllick and Hamschmidt 1999; Andrews, 2003). All of these are areas in which direct cost savings can be made because the environmental goods involved have to be purchased.

There is widespread agreement that EMS have largely failed to broaden the scope of corporate environmental management because they do not systematically address environmental concerns outside the factory gate, for example transport and logistics, sourcing of raw materials and other inputs, product design and end-of-life considerations (cf Steger 2000; Hamschmidt 2000; Kuisma et al 2001; Jäger et al 1998; Ankele et al 2002).

levels of operator performance (and different aspects of performance), with faster rates of improvement and with the likelihood of enforcement action.

4. Analysing the link between EMS and environmental performance

4.1 The MEPI approach

The following analysis reports research carried out in the context of the Measuring Environmental Performance of Industry (MEPI) study (cf Berkhout et al 2001; Tyteca et al 2001) in which the authors were investigators. The MEPI project operationalised performance as the environmental efficiency of the production process: *the level of input of energy and materials and the level of output of waste and pollution per unit of product output*. In the fertiliser and printing sectors, where there was insufficient data on production output, environmental indicators were normalised on turnover and number of employees respectively. All inputs and outputs were measured in physical terms such as weight or volume. The project covered six industrial sectors (electricity generation, pulp and paper, fertilisers, textile finishing, book and magazine printing, and computer manufacture) and six European countries (Austria, Germany, Italy, Belgium, the Netherlands and the UK). Within this limited scope, the project team aimed to collect data on environmental performance for as many companies and production sites as possible. Data were collected from three types of sources:

- 70 to 80% of the data stems from corporate environmental and financial reports as well as EMAS statements
- around 10 % of the data were taken from national pollution inventories (UK: fertilizer and paper, Netherlands: electricity)
- between 10 and 20% of the data was collected through specially-designed questionnaires in sectors where little public data was available (Italy: all sectors, UK: printing and textiles).

We estimate that for the more concentrated sectors (paper, electricity and fertilisers) the MEPI data set covers between 50 and 80 % of production in the six countries. In the sectors dominated by smaller companies (printing and textile finishing), the data covers less than 20% of production (see table 2). The computer manufacture sector was not included in the analysis because very little data was found. The data set covers the years 1985, 1990, and 1994 to 1998.

TABLE 2 ABOUT HERE

While the database with more than 15,000 performance data points for 274 firms and around 400 production sites provides a valuable research resource, it also has a number of significant limitations:

- The data set is incomplete, with many missing values. On average, only 28% of the performance indicators for which we collected data were available for a given firm or site in a given year. Principal component analysis (PCA) was carried out to establish that environmental performance could adequately be reflected by a subset of all indicators. For example, CO2 emissions were found to be indicative of all air emissions in the electricity sector (cf Berkhout et al 2001). This enabled us to restrict the analysis to a smaller number of indicators for which data were more complete and to reduce the need to aggregate indicators.
- A number of sectors consist of a heterogeneous set of firms, which have a structurally different environmental profile because they produce different products and/or use different technologies. Some - but not all - of these differences have been captured through the analysis of sub-sectors.
- The data set covers a period up to 1998, only few years after the introduction of the EMAS scheme (1995) and the ISO 14001 standard (1996). The analysis is, therefore, unable to cover the long-term effects of the adoption of formal EMS. On the other hand, the use of data from the mid to late 1990s was an opportunity to study a relatively large number of companies adopting the new EMS standards at that time.
- A significant share of the data has undergone little or no third party validation. Given that much of the data is disclosed voluntarily, however, we would not expect companies to consciously falsify performance data.
- In some sectors, the sample of firms is assumed to over-represent large companies and good performers, since we expect that these would have a higher propensity to publish data and reports.

4.2 Analysis

In the remainder of the section, we report three ways in which the link between EMS and environmental performance was analysed. Throughout the analysis, the 'presence of an EMS' was operationalised as the presence of a management system that is certified to an internationally-recognised standard (ISO 14001 or EMAS). A company was counted as being EMAS certified if *all* its production sites had adopted this standard. The link between EMS and environmental performance was investigated through examination of three hypotheses:

Hypothesis 1: Firms with an EMS have a better environmental performance than those without an EMS

We aimed to establish whether firms with a certified EMS performed better than those without. Given the input of management effort in the form of new practices, better coordination and greater monitoring, we would expect to find that firms with an EMS would record better performance overall than those without. Andrews (2003) found that across a panel of firms, performance indicators for which targets and objectives had been set showed a more consistent pattern of improvement, when compared with all environmental performance indicators.

Analysing every sector individually, we established significant differences between individual normalised performance levels achieved by EMS firms and those displayed by non-EMS firms based on non-parametric analysis. The analysis used those indicators that were identified as being most suitable by the Principal Component Analysis (PCA).[3] Non-parametric tests, which do not assume a normal distribution, were chosen since some indicators had skewed distributions. Missing values were treated on a case-by-case basis (pair-wise exclusion): where data for a specific indicator was missing, this firm was excluded in the testing for only this variable. Due to the large number of missing variables, the analysis did not control for any firm characteristics other than industrial sector and firm size (by means of normalisation, as described in section 4.1).

[3] Six performance indicators were identified in the PCA for the fertilisers sector (NO_x, VOC, hazardous and municipal waste, water use and energy use), 9 indicators for the pulp and paper sector (water use, energy use, solid waste, hazardous waste, CO_2, COD, SO_2, nitrogen and phosphorus), 9 indicators for the printing sector (hazardous and total waste, CO_2 and SO_2, ink use, isopropyl alcohol use, water use, fuel use and energy use), 11 indicators for textile finishing (total and recycled waste, CO_2, NO_x, VOC, COD, copper, chromium,

TABLE 3 ABOUT HERE

Overall, three conclusions can be drawn from the results (see Appendix and Table 3). First, the tests show that, in the large majority of cases, companies with an EMS did not perform significantly better than those without. In particular, significant differences could be identified for the environmental performance variables analysed in only three of the five sectors analysed and for only a minority of indicators. Significant differences (up to the 0.10 level) were found for individual normalised performance levels in the fertiliser sector (50% of indicators), printing (33%), and pulp and paper (22%), but not in the textiles and electricity sectors (see table 3). The complete absence of significant differences in two sectors, together with the fact that only a minority of indicators showed significant differences in the other three sectors, is notable, and suggests that hypothesis 1 is rejected on this evidence.

Second, in those sectors where significant differences were found, there were fewer instances in which EMS firms were significantly more eco-efficient as non-EMS firms: 50% of the significant differences were *pro* EMS firms in the paper sector and 33% in the fertilizer and printing sectors. In each sector where significant differences existed, results were found pointing in both directions, with the slight majority of cases recording negative correlations between a certified EMS and environmental performance. In the fertiliser sector, for example, NO_x emissions per unit of sales were lower for firms with EMS, whereas hazardous waste and VOC emissions per unit of sales were higher for firms with EMS. These different directions of an EMS-effect show that even though there are significant differences between firms with a certified EMS and those without, these do not necessarily imply that the certified firms perform better. This is further evidence to reject hypothesis 1.

Overall, the few and to some extent ambiguous differences suggest that EMS do not correlate strongly with corporate environmental performance. However, alternative explanations are possible:

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phosphorus, and energy use) and 13 indicators for electricity generation (solid waste, municipal waste, recycled waste, CO_2, NO_x, SO_2, dust, coal use, gas use, oil use, renewable fuel use and total fuel use).

- The methods adopted to operationalise both the presence of an EMS and environmental performance may not be sufficiently precise and nuanced to capture an EMS-effect. Many companies have EMS, but are not certified, for instance.
- An EMS-effect may have been disguised by the stronger influence of other explanatory variables some of which have been captured in the data (e.g. country, sub-sector, company size), while others have not (e.g. technologies, market conditions, management culture).
- Because EMS are a voluntary instrument, the link between EMS and performance may be influenced by inverse causality (the problem of endogeneity). If it is the case that poorly performing firms tend to adopt EMS because they feel the need to improve performance or to signal commitment, the lack of significant differences could be due to a lower performance baseline, rather than the ineffectiveness of EMS. It seems more likely, however, that in the majority of cases the act of EMS adoption suggests stronger environmental commitment (Hamschmidt, 2000). In this case, the absence of a strong correlation between EMS and performance is all the more surprising. In light of the current lack of one unified theory of EMS adoption (Russo (2001), for example, provides arguments for both lines of reasoning), these last two aspects seem to be essentially empirical questions. The trend analysis testing Hypothesis 3 tries to address this problem of causality.

Another issue which could influence the validity of results is whether EMS firms have reported data on a significantly lower number of indicators than non-EMS firms, perhaps even choosing not to report data in areas of poor performance. If this were the case, then a test for significant differences would likely underestimate a positive effect of EMS certification, since the performance levels of uncertified firms would be upward-biased.

Table A.5 reports the results of tests for significant differences in reporting between EMS and non-EMS firms. Overall, it is found that only in one instance was there a significant difference in the average number of indicators reported - with ISO-certified firms in the paper industry having a significantly lower number. This largely rejects the notion that uncertified firms under-report their performance strategically. In cases where differences are insignificant, both patterns of reporting are observed, i.e. there are sectors where the average number of indicators is higher for EMS firms (e.g. fertilizers) but also sectors where the average number of indicators is higher for non-EMS firms (e.g. electricity and printing), as can be seen from the mean differences of the T-tests reported in Table A.5. The tendency seems to be that uncertified firms report as least as much as certified ones. Therefore, it seems unlikely that our results can be explained through a bias resulting from non-EMS firms systematically reporting lower numbers of indicators.[4]

Hypothesis 2: Sites with an EMS have a better environmental performance than those without an EMS

We aimed to establish whether production sites of firms operating in a specific sector with a certified EMS performed better than those without an EMS. Although some intervening factors (scale, location) might play a greater role at this scale of analysis, we would be controlling for the observation that some firms operate a mix of certified and uncertified production sites. In addition, by looking at sites we sought to investigate whether differences existed between ISO 14001 and EMAS.

Again, we analysed sectors individually and focused on core indicators identified through the PCA. Because this approach required a more comprehensive data set, the sub-set of the data with the most consistent coverage was used (i.e. electricity and paper sectors, 1995 to 1997 data). Rankings were constructed on the basis of CO_2, SO_2, and NO_x (electricity) and NO_x, water use and Chemical Oxygen Demand (COD) discharge (paper).

Compared to the firm-level tests, the analysis was refined in two ways. First, different years were analysed individually. Second, the analysis was largely based on rankings derived from an aggregation of indicators based on the Jaggi and Freedman (1992) model which normalizes performance to a best-practice frontier. Calculating an aggregate index based on this model requires data on inputs, desirable outputs (products), and undesirable outputs (e.g. emissions) for a set of analogous units (e.g. firms) with comparable activities (e.g. in the same sector) (Tyteca et al. 2002; Berkhout et al. 2001: 140). The principle for calculating the index is to make reference to the units that perform best among the given set, i.e., those that have the lowest emissions per unit of production output. The index value is 1 for the unit(s) performing best for all variables considered. The index values for all

[4] It should also be noted that the lack of significant links between EMS and performance contrasts with other hypotheses tested where significant statistical associations were found more consistently (for example between EMS and company size, EMS and profitability, cf. Berkhout et al 2001).

other units are less than 1, but larger than zero.[5] This index calculated according to the Jaggi and Freedman (1992) model treats variables as independent (Tyteca et al. 2002), rather than considering them simultaneously in a multi-dimensional space (as e.g. in Tyteca 1999). Three different Jaggi/Freedman ranking methods were tested and compared: 1) Jfadj where the variant is adjusted to account for variables with zero values, 2) Jfmiss where a maximum of one missing variable is allowed, and 3) Jfagr where SO2 and NOx emissions were aggregated using acidifying equivalence coefficients (see Tyteca et al (2002) for fuller descriptions of the aggregation based on the Jaggi/Freedman model).

As with the firm-level analysis, some correlations between EMS and performance were found, but in general correlations were weak, sometimes ambiguous and usually not statistically significant. The results can be summarised as follows:

For the electricity-generating sector, in both 1996 (see Figure 1) and 1997 (similar result), sites with ISO 14001 performed worse across the basket of indicators than those without. Sites with EMAS performed slightly better than non-EMAS sites in 1997, but for 1996 data no effect could be detected. None of the results was statistically significant. For the paper and pulp sector there was only one significant result: sites with ISO as well as sites with EMAS had lower COD discharge (1996 and 1997) than those without (see Figure 2).

FIGURE 1 ABOUT HERE

FIGURE 2 ABOUT HERE

Overall, only a few and contradictory correlations between EMS adoption and environmental performance were found at the site-level. This confirms the results at the firm-level.

Hypothesis 3: Sites improve their environmental performance trend after adopting an EMS

Finally, the performance of production sites over time was evaluated to test the hypothesis that environmental performance improves when an EMS is adopted. Here, each indicator was analysed individually, assessing whether the performance trend improved in the years

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[5] If the minimum emission in the data is equal to zero, one can use as minimum value an arbitrary, strictly positive value, which is smaller than the smallest emission value different from zero in the data (Berkhout et al. 2001: 141).

after EMS adoption. Such a longitudinal analysis of the EMS effect should eliminate many of the methodological difficulties and possible alternative explanations discussed above, particularly the endogeneity issue (the question whether good or bad performers are more likely to adopt EMS) and the problem of intervening variables such as country, sub-sector or company size.

The analysis was based on all performance time-series of three or more years where a certified EMS was introduced during that period (but not in the first or last year of the series). We established the trend before and after the adoption of the EMS over all available years using a 'least square' method and calculated the *difference* between both trends. The year before EMS adoption is included as endpoint in the trend 'before adoption' and as starting point in the 'trend after adoption' (Figure 3). The database contained 165 of these performance time series related to 24 different production sites (that is, each site was represented by an average of seven performance indicators) in four sectors: electricity generation, pulp and paper, fertiliser and textile finishing.

Looking at the performance trend over the *entire* period measured, we found that a small majority of indicators (59%) had improved, while in 41% of cases there was an increase in specific inputs, emissions or waste. Only 10 of the 24 sites (42%) had a majority of improving indicators, while the other 14 saw either a majority of deteriorating trends (29%) or an equal number of upwards and downwards trends (29%). To assess the EMS effect, we then examined whether EMS adoption resulted in a relative change of trend in performance. In this sense, an EMS is also seen to be effective if it lowers the rate at which the performance worsens. When analysing the trend of all indicators individually, we found that the performance trend after EMS adoption improved in 99 cases (60%), worsened in 59 cases (36%) and remained unchanged in 7 cases (4%). Given that we would expect an equal distribution between improving and worsening trends if there was no EMS effect, this suggests that the adoption of an EMS appears to have had an impact only on a small minority of performance measures. When the data was aggregated by production site, a similar picture emerged. Fourteen sites (58%) saw a trend improvement on most indicators in the years after EMS adoption, while six (25%) saw predominantly a decline and the remaining four (17%) saw an equal number of improving and declining trends.

FIGURE 3 ABOUT HERE

Because the structure of the data (varying length of time series, different start and end points, different measurements units) did not allow for the use of more formal statistical methods in the longitudinal analysis, we made a simple calculation of trend change expressed as percentage of average environmental impact. The results cannot be considered as statistically significant. The 165 time-series used in this analysis are, however, environmentally significant as they represent considerable materials flows from large industrial installations.

In the 99 cases where the performance trend became more favourable after EMS adoption, it improved on average by 36 percentage points (e.g. from a 20% annual increase of emissions before adoption to a 16% decrease after adoption). In the 59 cases where the trend became more unfavourable, it worsened on average by 52 percentage points. The large change reflects the strong variability of environmental performance over time (cf. Berkhout et al, 2001).

Further analysis generated several other findings:

- There was a high variability between sectors, with only the paper sector showing a strong EMS effect (see Figure 4).
- There was no clear difference between the effects of EMAS and ISO14001.
- There was no strong difference between environmental indicators where the level of performance is directly related to economic costs (e.g. hazardous waste, energy use) and those where cost was not a factor (noise, most air and water emissions).

FIGURE 4 ABOUT HERE

Overall, the analysis suggests that the adoption of EMS has a certain positive impact on the performance trend of a small minority of indicators. Due to the limited number of cases studied and the inherent variability of performance, it is not possible to reliably indicate the magnitude of the effect. That the third test has not identified an EMS effect for a larger number of indicators is surprising because the longitudinal approach is a more targeted method of evaluating the 'EMS hypothesis' and should make actual performance effects visible. This seems to confirm the previous finding that the link between EMS and performance is weak. To draw firmer conclusions, it would be necessary to carry out this sort of longitudinal analysis with longer time series because it is conceivable that performance impacts of EMS are lagged (Anton et al, 2004), with effects observable only after a number of years of management effort. This may be because companies need time to adjust to newly-introduced routines, because improvements are incremental or because there are periodic windows of opportunity for substantial improvement through the adoption of new technologies (e.g. related to investment cycles). The effect of a 'learning lag' is well known in the literature on the relationship between innovation and productivity, which finds that companies suffer productivity losses during the period immediately after the introduction of an innovation (Conceição et al 2003).

5. Conclusions: The EMS / performance link

The data on the environmental performance we have analysed in this paper provides little evidence that companies or production sites that have adopted a certified EMS perform significantly and consistently better than those without. Possible explanations for this finding are:

- EMS are not a consistently strong driver of environmental performance improvement.
- The limits of data availability do not allow an analysis sufficiently precise and nuanced to distinguish the effect of EMS on environmental performance.
- The EMS effect is not sufficiently large to outweigh other stronger determinants of environmental performance or factors which determine year-on-year variations (e.g. plant utilisation, product specification, investment cycle).
- EMS are a driver of environmental performance improvement, but the areas of improvement lie outside the performance dimensions captured by MEPI eco-efficiency indicators (e.g. logistics, product performance, business travel).

In our view it is unlikely that the analysis presented here has failed to detect a strong EMS / performance link merely because environmental improvements occurred in areas other than the environmental efficiency of production. Qualitative research reported in section 3 found that EMS have not usually broadened the scope of environmental management to include impacts outside the factory gate (cf Steger 2000; Hamschmidt 2000; Hamschmidt & Dyllick 2001; Kuisma et al 2001; Jäger et al 1998; Ankele et al 2002). This suggests that if an EMS / performance link exists, it would be found in the functions examined in the MEPI study. A more plausible interpretation is that EMS have proven only a relatively weak driver of environmental performance. In particular, the result of the longitudinal analysis that the trend in performance frequently worsened after the adoption of an EMS can only reasonably be explained through the presence of other influencing factors.

What could be the reasons for the limited environmental effectiveness of EMS? Our analysis does not provide a positive explanation of these findings. Interpreting the results in the light of previous research into EMS, we would like to propose a number of possible explanations. First, the results appear to confirm the view of other evaluation studies that EMS are a tool for performance improvement, rather than a driver of change. Put differently, EMS may in fact be a necessary, rather than a sufficient condition for successful efforts to reduce resource use and emissions. Taken together with Hamschmidt's (2000) result that environmental performance is not usually the main motive for companies to adopt an EMS, a weak EMS / performance link becomes a plausible result.

Second, the modest effectiveness of EMS could also be due to shortcomings in the implementation and enforcement of current procedures rather than implying a fundamental criticism of EMS. A number of studies have shown that the outcome of EMS depends strongly on the way in which they are put into practice ((Coglianese and Nash, 2001; Thornton, Kagan and Gunningham, 2003). Current environmental management standards are believed to encourage companies to implement EMS in a formalistic and procedural way (Dyllick and Hamschmidt 1999). Third, it is also possible that improvements are made only under certain circumstances, for example in sectors with short investment cycles, or in countries with less stringent regulations and enforcement. The MEPI analysis did not collect data that would allow identification of those conditions under which EMS tend to have an impact on performance.

Fourth, procedural improvements made through the introduction of an EMS may not lead to environmental improvement because of cost barriers. Although EMS have been found to help companies identify cost-effective environmental measures (Steger 2000), the results from this study suggest that the effect of these measures could be small when compared to the overall environmental impact of the company. It remains an open question whether this is due to shortcomings of the EMS tool (e.g. focus on ability to manage current processes rather than improving the innovative capacity), or whether it implies a more sober view with regard to the overall potential for win-win solutions.

Given the uncertainty about how the results can be explained, policy recommendations need to be made with care. We do not believe it would be appropriate to conclude either that EMS are ineffective, or that that policy support for EMS should be withdrawn. Any conclusion about the link between EMS and environmental performance is necessarily preliminary, because more comprehensive data are needed and long-term effects have not yet been studied. Moreover, EMS may have benefits other than environmental performance - for example in terms of regulatory certainty, internal and external communication or awareness raising - that may justify policies encouraging their diffusion.

The weak link between EMS and performance is, however, a matter of concern if EMS are envisaged as serving as a substitute for other policy instruments. Scaling-back regulation or environmental taxes for firms with EMS (often referred to as ‘regulatory relief’) is practiced or under consideration in many European countries, for example in the form of fewer inspections by regulators, reduced rates for plant licences, or exemptions from environmental charges (Wätzold et al 2001; Dahlström et al 2003). On the basis of the research presented, we would argue that there is currently no evidence to suggest that EMS have a *consistent* and *significant* positive impact on environmental performance. Any substantial regulatory relief based on the simple assumption that companies with an EMS perform better than those without would therefore be inappropriate.

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Appendix: Detailed test statistics for firm-level analysis of MEPI data

Table A.1: Test Statistics for EMS effects in the Electricity & Fertiliser Sectors (Exact Tests; ISO & EMAS firms identical; FU: Functional Unit, here: MWh for Electricity and total sales for Fertilisers)

Variable (Electricity, EMAS only)	Sample size	Mann-Whitney U	Wilcoxon W	Z	Exact significance (2-tailed)	Exact significance (1-tailed)	Variable (Fertilisers, EMAS/ISO)	Sample size	Mann-Whitney U	Wilcoxon W	Z	Exact significance (2-tailed)	Exact significance (1-tailed)
CO_2 emissions per FU	64	39.00	42.00	-0.887	0.417	0.208							
NO_x emissions per FU	68	30.00	33.00	-1.307	0.225	0.112	NO_x per total sales	13	2.00	5.00	-1.776	0.103	0.051
SO_2 emissions per FU	70	39.00	42.00	-1.022	0.347	0.173	VOC per total sales	8	0.00	21.00	-2.000	0.071	0.036
Dust emissions per FU	21	18.00	21.00	-0.120	0.943	0.471							
Total solid waste per FU	50	24.00	27.00	-1.188	0.276	0.138	Hazardous waste per total sales	8	0.00	21.00	-2.000	0.071	0.036
Municipal waste per FU	48	21.00	1149.00	-0.180	0.917	0.458	Municipal waste per total sales	6	0.00	10.00	-1.852	0.133	0.067
Recycled waste per FU	43	21.00	924.00	0.000	1.000	0.512	Total water per total sales	25	20.00	23.00	-0.301	0.807	0.403
Coal input per FU	54	21.00	1452.00	-0.367	0.833	0.407							
Total fuel input per FU	6	1.00	2.00	-0.878	0.667	0.333							
Gas input per FU	56	20.00	21.00	-0.464	0.750	0.375							
Total oil input per FU	54	24.00	25.00	-0.160	0.926	0.463							
Renewables input per FU	6	0.00	1.00	-1.464	0.333	0.167							
Total energy input per FU	4	0.00	1.00	-1.342	0.500	0.250	Total energy per total sales	22	9.000	12.000	-1.256	0.260	0.130

Note: for all Tables A.1 to A.5, existence of EMAS or ISO certification was coded “1”, the case that a firm did not have any certification was coded “2”)

Table A.2: Test Statistics for EMS effects in the Paper Sector (Exact Tests; ISO & EMAS separate; FU: Functional Unit, here: tonne of paper produced)

Variable (Paper, EMAS only)	Sample size	Mann-Whitney U	Wilcoxon W	Z	Exact significance (2-tailed)	Exact significance (1-tailed)
CO_2 per FU	51	132.00	1167.00	-0.088	0.943	0.472
SO_2 per FU	29	37.00	47.00	-0.822	0.444	0.222
Total solid waste per FU	46	63.00	1009.00	-0.067	0.967	0.483
Recycled waste per FU	68	97.00	107.00	-0.808	0.441	0.220
COD per FU	90	127.00	155.00	-2.463	0.012	0.006
Nitrogen per FU	75	44.00	47.00	-0.954	0.381	0.191
Phosphorus per FU	46	22.00	25.00	-1.185	0.278	0.139
Total energy input per FU	36	1.00	596.00	-4.754	0.003	0.003
Total water input per FU	101	443.00	498.00	-0.136	0.898	0.449

Variable (Paper, ISO only)	Sample size	Mann-Whitney U	Wilcoxon W	Z	Exact significance (2-tailed)	Exact significance (1-tailed)
CO2 per FU	53	175.00	211.00	-0.124	0.913	0.456
SO2 per FU	29	27.00	37.00	-1.455	0.160	0.080
Total solid waste per FU	46	120.00	148.00	-0.505	0.632	0.316
Recycled waste per FU	68	150.00	178.00	-1.282	0.208	0.104
COD per FU	92	266.00	344.00	-2.481	0.012	0.006
Nitrogen per FU	77	189.00	217.00	-0.992	0.332	0.166
Phosphorus per FU	48	60.00	70.00	-1.044	0.318	0.159
Total energy input per FU	36	18.00	579.00	-3.761	0.009	0.009
Total water input per FU	104	579.00	684.00	-0.486	0.634	0.317

Table A.3: Test Statistics for EMS effects in the Textile Sector (Exact Tests; no ISO-certified firms; FU: Functional Unit, here: unit of textiles produced)

Variable (Textiles, EMAS only)	Sample size	Mann-Whitney U	Wilcoxon W	Z	Exact significance (2-tailed)	Exact significance (1-tailed)
CO_2 per FU	23	35.00	56.00	-1.121	0.280	0.139
NO_x per FU	33	79.00	100.00	-0.093	0.940	0.470
Total water per FU	55	28.00	31.00	-1.124	0.302	0.151
VOC per FU	16	5.00	6.00	-0.543	0.750	0.375
Recycled waste per FU	34	71.00	477.00	-0.587	0.577	0.289

Variable (Textiles, EMAS only)	Sample size	Mann-Whitney U	Wilcoxon W	Z	Exact significance (2-tailed)	Exact significance (1-tailed)
COD per FU	32	76.00	427.00	-0.097	0.944	0.472
Phosphorus per FU	15	6.00	97.00	-1.189	0.305	0.152
Total energy input per FU	65	34.00	37.00	-1.102	0.311	0.155
Total solid waste per FU	38	20.00	686.00	-1.046	0.344	0.172

Note: whilst copper/chromium emissions to water were included in the PCA, no data for firms with certified EMS was available and therefore tests could not be carried out

Table A.4: Test Statistics for EMS effects in Printing Sector (Exact Tests; ISO & EMAS separate)

Variable (Printing, EMAS only)	Sample size	Mann-Whitney U	Wilcoxon W	Z	Exact significance (2-tailed)	Exact significance (1-tailed)	Variable (Printing, ISO only)	Sample size	Mann-Whitney U	Wilcoxon W	Z	Exact significance (2-tailed)	Exact significance (1-tailed)
Carbon dioxide per employee	14	4.00	7.00	-1.461	0.198	0.099	Carbon dioxide per employee	14	5.00	6.00	-0.372	0.857	0.429
Sulphur dioxide per employee	15	10.00	25.00	-1.839	0.071	0.034	Sulphur dioxide per employee	15	10.00	25.00	-1.839	0.071	0.034
Total waste per employee	36	73.00	508.00	-1.139	0.267	0.133	Total waste per employee	36	63.00	498.00	-1.539	0.129	0.064
Hazardous waste per employee	25	42.00	252.00	-0.543	0.621	0.311	Hazardous waste per employee	25	55.00	245.00	-0.127	0.926	0.463
Total ink input per employee	51	186.00	252.00	-0.779	0.445	0.223	Total ink input per employee	51	179.00	245.00	-0.939	0.356	0.178
Isopropyl alcohol input per employee	26	11.00	336.00	-0.200	0.923	0.462	Isopropyl alcohol input per employee	26	33.00	39.00	-0.121	0.928	0.464
Total fuel input per employee	39	105.00	633.00	-0.256	0.812	0.406	Total fuel input per employee	13	121.00	166.00	-0.467	0.654	0.327
Total energy input per employee	38	73.00	101.00	-1.337	0.190	0.096	Total energy input per employee	38	71.00	116.00	-2.043	0.041	0.021
Total water input per employee	42	102.00	147.00	-1.425	0.161	0.081	Total water input per employee	42	96.00	162.00	-2.131	0.033	0.016

Table A.5: Test Statistics for significant differences of the number of indicators for which data was available between EMS and non-EMS firms (Exact Tests)

Sector (non-parametric test)	Sample size	Mann-Whitney U	Wilcoxon W	Z	Exact significance (2-tailed)	Sector (parametric test)	Sample size	Mean difference	Standard deviation of difference	T	Significance
Electricity	79	98.00	104.00	-0.430	0.680	Electricity	79	-0.921	3.804	-0.242	0.831
Fertilizer	60	42.50	1695.50	-1.581	0.188	Fertilizer	60	2.772	0.894	1.380	0.300
Paper (EMAS)	184	1422.50	1722.50	-2.472	0.013	Paper (EMAS)	184	-1.471	0.498	-2.956	0.004
Paper (ISO)	197	2503.50	3064.50	-0.824	0.413	Paper (ISO)	197	0.013	0.262	0.051	0.960
Textiles	109	385.00	5435.00	-0.724	0.477	Textiles	109	0.297	0.547	0.543	0.596
Printing (EMAS)	74	392.00	528.00	-0.916	0.339	Printing (EMAS)	74	-0.625	0.688	-0.908	0.367
Printing (ISO)	74	346.00	2176.00	-1.038	0.302	Printing (ISO)	74	0.695	0.723	0.962	0.339

Note: Table also includes the EMS and non-EMS firms for which the number of indicators was zero, i.e. which could not be included in Tables A.1 to A.4. Only 2-tailed (exact) significance values for non-parametric tests are reported since these are more appropriate for comparing count distributions. Since the distribution of the number of indicators may be less skewed than that of the individual indicators, parametric tests are also reported. For the latter, only the appropriate statistics are reported depending on whether the Levene-test for equal vs. unequal variances was significant or not. As before, the presence of EMAS or ISO certification was coded as “1”, the absence as “2”.

Table 1: Key studies on the environmental effectiveness of EMS

Study	Funder	Approach and sample	Results regarding EMS / environmental performance link
Potoski and Prakash 2005	Own universities	Treatment effects analysis of ISO14001 certification on facilities' emissions	Some evidence that ISO-certified facilities experience larger reductions in pollution emissions
Anton et al 2004	US Environmental Protection Agency (USEPA)	Econometric study of links between environmental management practices in firms and toxic release intensities	More comprehensive EMS have a significant negative impact on intensity of toxic releases, with greater impact in firms with poor past environmental record
Dahlström et al 2003	UK Environment Agency (EA)	Statistical analysis of the link between EMS and regulator's assessment of performance for 800 sites	Better procedural performance but no impact on likelihood of incidents, complaints or non-compliance events
Andrews 2003	US Environmental Protection Agency (USEPA)	Longitudinal study of 25 industrial facilities, comparing performance before and after EMS implementation	56% of cases reported improved performance in at least half of their environmental indicators
Kuisma et al 2001	Finnish Ministry of the Environment	In-depth study of Finnish paper industry; qualitative and quantitative	Improvements in waste and risk management; weak on product development
Hamschmidt 2000	Swiss Agency for the Environment	Self-assessment by 158 companies	10%: large improvement 60%: small improvement 30%: deterioration / unknown
Steger 2000	Ministries for the Environment in Germany and Austria	Review of 24 empirical studies, most based on self-assessment questionnaire	Better compliance, some cases of improvement identified but no fundamental change
FEU 1998	German Ministry for the Environment	Self-assessment of 27 companies, analysis of 200 env'l statements	Better compliance but no quantitative information on performance
UNI/ASU 1997	German Federal Foundation for the Environment	Self-assessment of 723 companies, largely qualitative	Cases of improvement identified but no quantitative information on performance

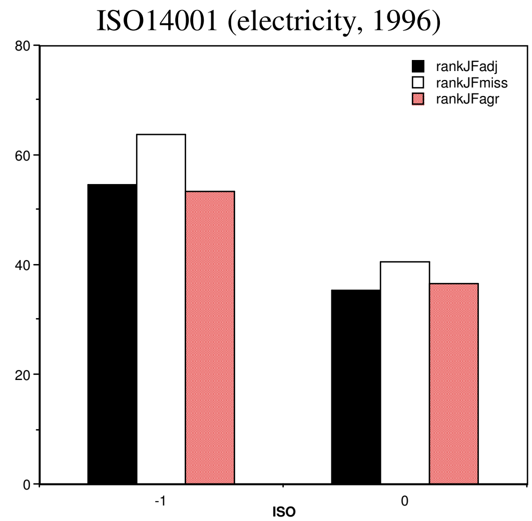
Table 2: Number of firms for which data was collected (by sector and country)

Country	*Computer*[6]	Electricity	Fertilisers	Paper	Printing	Textile	All
Austria	*0*	9	0	8	2	1	20
Belgium	*n.a.*[7]	2	4	4	4	5	19
Germany	*5*	27	2	43	33	13	123
Italy	*4*	6	7	10	5	11	43
Netherlands	*0*	4	7	17	0	14	42
United Kingdom	*0*	10	6	8	2	1	27
All countries	*9*	58	26	90	46	45	274

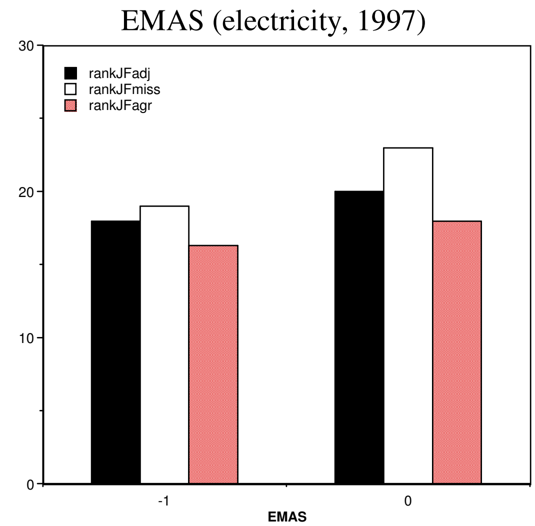
[6] Not included in analysis due to a lack of data.
[7] No significant activities in this sector.

Table 3: Summary of results at the firm level

Industry sector	Variable	Performance level for firms with certified EMS
Fertilisers	NO_x per unit of sales	lower (with ISO/EMAS)
	Hazardous waste per unit of sales	higher (with ISO/EMAS)
	VOC emissions per unit sales	higher (with ISO/EMAS)
Pulp/Paper	COD per tonne of paper	lower (with ISO/EMAS)
	Energy input per tonne of paper	higher (with ISO/EMAS)
Printing	Water input per employee	lower (with ISO/EMAS)
	SO_2 per employee	higher (with EMAS/ISO)
	Energy input per tonne of paper	higher (with EMAS/ISO)

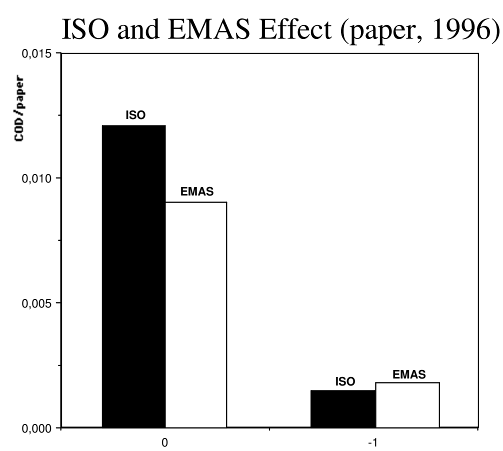


Relationship between ISO14001 and JF ranking ("-1" = site ISO certified, "0" = site not ISO certified)



Relationship EMAS and JF ranking ("-1" = site EMAS certified, "0" = site not EMAS certified)

Figure 1: EMS effect on the site-level (electricity)



Influence of ISO and EMAS certification on COD ("0" = site not certified, "-1" = site certified)

Figure 2: EMS effect on the site-level (paper)

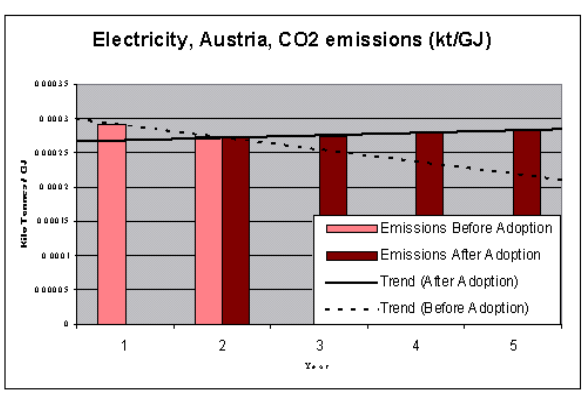


Figure 3: Example of performance trend series (EMS adopted in year 3)

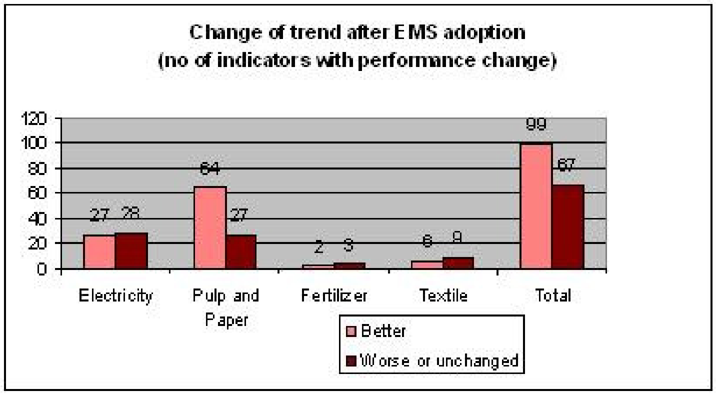


Figure 4: Change of performance trend after EMS adoption (by sector)